

What is claimed is:

- 1 1. A computer implemented method for enumerating sets of concurrently
2 scheduled events for automatic validation, the method comprising, in a
3 programmed computer system:
 - 4 a) providing a universal master schedule comprising a plurality of time
5 period data records (TPDRs) each having a start time and an end time, at
6 least some of the TPDRs comprising references to events, each event
7 having an overall start time and an overall end time, the events including
8 recurring events each having a period;
 - 9 b) retrieving a TPDR from the universal master schedule;
 - 10 c) establishing a time limit for the TPDR;
 - 11 d) performing a time-based iteration to identify sets of concurrent events
12 by:
 - 13 1) establishing the start time of the TPDR as a selected time;
 - 14 2) identifying a set of zero or more events occurring at the selected
15 time;
 - 16 3) creating a record of the set of zero or more events occurring at
17 the selected time;
 - 18 4) identifying a new selected time corresponding to a next time
19 when an event referenced by the TPDR could start or stop; and,
 - 20 5) repeating actions (2) to (4) until the new selected time is in
21 excess of the time limit;
 - 22 and,
 - 23 e) performing actions (b) through (d) for each TPDR in the universal
24 master schedule.
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- 1 2. The method of claim 1 wherein the time limit is a lesser one of a least common
2 multiple of the periods of any recurring events reference by the TPDR and a
3 length of the TPDR.

1 3. The method of claim 1 wherein the events comprise single-shot events and the
2 method comprises determining whether all events associated with a TPDR are
3 single-shot events and, if so, recording the set of single-shot events associated
4 with the TPDR as a set of concurrent events for validation.

1 4. The method of claim 1 wherein providing the universal master schedule
2 comprises:

- 3 a) providing a plurality of master schedule data structures, each master
4 schedule data structure corresponding to a resource and comprising one
5 or more TPDRs each associated with a time period;
- 6 b) collapsing the plurality of master schedule data structures into the
7 universal master schedule data structure by:
- 8 1) providing an initial universal master schedule data structure
9 comprising at least one TPDR;
- 10 2) selecting one of the TPDRs from one of the master schedule data
11 structures as a current TPDR;
- 12 3) if necessary, modifying the universal master schedule data
13 structure so that the start time of the current TPDR corresponds
14 to the end time of one TPDR of the universal master schedule
15 data structure and the start time of another TPDR of the universal
16 master schedule data structure - and the end time of the current
17 TPDR corresponds to the end time of one TPDR of the universal
18 master schedule data structure and the start time of another
19 TPDR of the universal master schedule data structure;
- 20 4) in the universal master schedule data structure, associating each
21 TPDR which has a start time greater or equal to the start time of
22 the current TPDR and a finish time less than or equal to the
23 finish time of the current TPDR with the events referenced by
24 the current TPDR; and,
- 25 5) repeating actions (2) through (4) for the remaining TPDRs of the
26 master schedule data structures.

- 1 5. The method of claim 4 wherein modifying the universal master schedule data
2 structure comprises, in either order:
3 locating a TPDR in the universal master schedule data structure for
4 which the associated time period includes the start time of the current TPDR
5 and, if the start time of the current TPDR is after the start time of the located
6 TPDR, replacing the located TPDR in the universal master data structure with
7 first and second altered TPDRs which differ from the located TPDR in that the
8 end time of the first altered TPDR and the start time of the second altered TPDR
9 are set to the start time of the current TPDR; and, locating a TPDR in the
10 universal master schedule data structure for which the associated time period
11 includes the end time of the current TPDR and, if the end time of the current
12 TPDR is after the start time of the located TPDR, replacing the located TPDR in
13 the universal master data structure with first and second altered TPDRs which
14 differ from the located TPDR in that the end time of the first altered TPDR and
15 the start time of the second altered TPDR are set to the end time of the current
16 TPDR.
- 1 6. The method of claim 4 wherein the initial universal master schedule data
2 structure comprises a selected one of the master schedule data structures.
- 1 7. The method of claim 4 wherein providing one or more of the master schedules
2 comprises:
3 a) providing a plurality of mini-schedule data structures, each mini-
4 schedule data structure having a priority, corresponding to a resource
5 and comprising one or more TPDRs each associated with a time period;
6 b) collapsing the plurality of mini-schedule data structures into the master
7 schedule data structure by:
8 1) providing an initial master schedule data structure comprising at
9 least one TPDR and selecting a lowest priority one of the mini-
10 schedules as a current mini-schedule;

- 2) selecting one of the TPDRs from the current mini-schedule as a current TPDR;
- 3) if necessary, modifying the master schedule data structure so that the start time of the current TPDR corresponds to the end time of one TPDR of the universal master schedule data structure and the start time of another TPDR of the universal master schedule data structure - and the end time of the current TPDR corresponds to the end time of one TPDR of the universal master schedule data structure and the start time of another TPDR of the universal master schedule data structure;
- 4) in the master schedule data structure, associating each TPDR which has a start time greater or equal to the start time of the current TPDR and a finish time less than or equal to the finish time of the current TPDR with the events referenced by the current TPDR;
- 5) repeating actions (2) through (4) for the remaining TPDRs of the current mini-schedule; and,
- 6) repeating actions (2) through (5) for each of the mini-schedules in priority order.

8. The method of claim 7 wherein modifying the master schedule data structure comprises in either order:

locating a TPDR in the master schedule data structure for which the associated time period includes the start time of the current TPDR and, if the start time of the current TPDR is after the start time of the located TPDR, replacing the located TPDR in the master data structure with first and second altered TPDRs which differ from the located TPDR in that the end time of the first altered TPDR and the start time of the second altered TPDR are set to the start time of the current TPDR; and,

locating a TPDR in the master schedule data structure for which the associated time period includes the end time of the current TPDR and, if the end time of the current TPDR is after the start time of the located TPDR,

13 replacing the located TPDR in the master data structure with first and second
 14 altered TPDRs which differ from the located TPDR in that the end time of the
 15 first altered TPDR and the start time of the second altered TPDR are set to the
 16 end time of the current TPDR.

1 9. The method of claim 7 wherein, in collapsing the plurality of mini-schedules,
 2 associating a TPDR with the events referenced by the current TPDR comprises,
 3 if the current TPDR is associated with a single-shot event, replacing any
 4 references to events referenced by the TPDR with a reference to the single-shot
 5 event.

1 10. The method of claim 9 wherein, in collapsing the plurality of mini-schedules,
 2 associating a TPDR with the events referenced by the current TPDR comprises,
 3 if the current TPDR is associated with one or more recurring events, adding
 4 references to the one or more recurring events to the TPDR.

1 11. The method of claim 1 wherein creating a record of the set of zero or more
 2 events comprises providing a bit vector having one bit for each of a number of
 3 possible events and setting a bit in the bit vector corresponding to each of the
 4 zero or more events.

1 12. The method of claim 11 wherein creating a record of the set of zero or more
 2 events comprises checking a bit vector repository to determine if the bit vector
 3 is the same as any bit vector already stored in the bit vector repository and, if
 4 not, storing the bit vector in the bit vector repository.

1 13. The method of claim 1 wherein the events each comprise enabling a specific
 2 QoS policy on a data communication network.

1 14. The method of claim 1 wherein the universal master schedule data structure
 2 comprises a B-tree.

- 1 15. The method of claim 1 wherein the universal master schedule data structure
2 comprises a skip list.
- 1 16. A program product comprising a computer readable medium containing
2 instructions which, when executed by a processor, cause the processor to
3 perform a method according to claim 1.
- 1 17. A universal master schedule data structure for use in a computerized system for
2 enumerating sets of concurrent events between a dawn of time and an end of
3 time, the universal master schedule data structure comprising a plurality of time
4 period data records (TPDRs), each comprising a start time of a corresponding
5 time period; an end time of a corresponding time period; and, references to zero
6 or more events capable of occurring within the time period, the events having
7 overall start times and overall end times; the time periods of the time period
8 data records being non-overlapping and continuous between the dawn of time
9 and the end of time wherein all of the overall start times and all of the overall
10 end times correspond to the dawn of time, the end of time or one of the start
11 times.
- 1 18. The data structure of claim 17 wherein the events comprise single shot events
2 and the references to the single-shot events each comprise a reference to a data
3 record comprising an overall start time; an overall end time; a preemption
4 priority of an associated mini-schedule; an identity of a resource for which this
5 event is scheduled; and, an event ID.
- 1 19. The data structure of claim 17 wherein the events comprise recurring events and
2 the references to the recurring events each comprise a reference to a data record
3 comprising an overall start time; an overall end time; a time pattern for
4 occurrences of the event within the overall period; a the length of the pattern's
5 period; a start time of the pattern instance that is in progress at the time of the
6 overall start time of the event; a list of one or more pairs of start dates and times

and end dates and times within the pattern; a preemption priority of an associated mini-schedule; an identity of the resource for which this event is scheduled; and, an event ID.

20. Apparatus for enumerating sets of concurrently scheduled events, the apparatus comprising:

- a) a first means for collapsing a plurality of mini-schedules into a master schedule;
- b) a second means for collapsing a plurality of master schedules into a universal master schedule, the second means connected to receive a plurality of master schedules generated by the first means; and,
- c) a third means for extracting a plurality of sets of concurrent events, the third means connected to receive a universal master schedule from the second means and to store a data record containing information identifying sets of concurrent events scheduled in the universal master schedule.

21. The apparatus of claim 20 wherein the third means comprises means for performing a time-based iteration.

22. The apparatus of claim 21 wherein the means for performing a time-based iteration comprises:

- a) means for establishing the start time of the TPDR as a selected time;
- b) means for identifying a set of zero or more events occurring at the selected time;
- c) means for creating a record of the set of zero or more events occurring at the selected time;
- d) means for identifying a new selected time corresponding to a next time when an event referenced by the TPDR could start or stop; and,
- e) means for repeating actions (b) to (d) until the new selected time is in excess of the time limit.

- 1 23. The apparatus of claim 20 comprising means for determining whether all events
2 in a set of concurrent events are single-shot.

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